HIGH-RESOLUTION SEISMIC SURVEYING FOR NEOGENE-QUATERNARY SEQUENCE STRATIGRAPHY, NORTHERN CALIFORNIA CONTINENTAL SHELF AND UPPER SLOPE, IN SUPPORT OF STRATAFORM

Gregory Mountain (P.I.)
Lamont-Doherty Earth Observatory of Columbia University
Palisades, NY 10964
phone: (914) 365-8540 fax: (914) 365-3181
email: mountain@ldeo.columbia.edu
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LONG-TERM GOALS

The goal of STRATAFORM is to link short-term biological and physical processes affecting sedimentation ("event" stratigraphy" developed over hours to weeks) to the stratigraphic geometry and facies distribution of the upper ~100 m of continental margin sediments representing ~10^6 years of preserved record.

OBJECTIVES

Three groups of processes have been isolated for study by STRATFORM investigators: 1) shelf sediment dynamics and the development of lithostratigraphy; 2) slope processes and their role in shaping geomorphology; and 3) stratigraphic sequence generation. Collecting high-resolution seismic reflection data as we have done is at the core of this third approach. All three are linked by our goal of determining how the morphology and facies patterns of the modern sea floor (revealed by multibeam bathymetry, backscatter data, and sampling of the shelf and slope) compare with the preserved geologic record observed in seismic images and sampled in the subsurface.

APPROACH

Funding from ONR and other sources allowed us to assemble the equipment needed to meet the stringent requirements of high-resolution reflection profiling. This included a generator-injector ("GI") airgun, a 48-channel 600-m narrow-gauge (solid, not oil-filled) analog streamer, and a robust digital recorder capable of the high sampling rates required (1msec). We determined from existing profiles that a track spacing of 800 m was optimal for covering the region of study in the time available while capturing the necessary detail of sub-seafloor features. We designed a survey grid to cover the area previously mapped with swath bathymetry and acoustic backscatter, tie to piston core transects, and duplicate several profiles with lower resolution (air gun) and higher resolution (Huntec) imaging that would allow us to "nest" these data types and evaluate their respective limits.

WORK COMPLETED

The cruise was a great success. We towed the gun at the same depth as our "bird"-controlled streamer (from 4 to 11 feet, depending on sea state), firing at a 12.5 m spacing to yield 24-fold stacking. We simultaneously acquired analog 3.5 kHz profiles from a hull-mounted transducer. The bridge steered pre-plotted track lines with the aid of DGPS navigation. We were surprised by strings of crab pots along the inner part of our proposed grid; they are a hazard to towed gear, and consequently we had to stay farther offshore than we originally intended. Nonetheless, in 17 days we recorded 2200 km of data onto 1014 tapes of 200 Mbytes each. Half of the field tapes were shipped to colleagues Fulthorpe and Austin at UTIG (PIs on separate, parallel grant). We are coordinating our processing efforts to ensure uniformity of product. Gathering sub-seafloor samples at depths well beyond the range of standard piston coring is an integral part of the STRATAFORM plan. Consequently, a 2-day workshop entitled "Marine Coring at Margiins" (MarineCAM) was convened by the PI at L-DEO. 28 scientists and 6 representatives from marine engineering companies

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attended to discuss the scientific goals and the technological realities of recovering complete cores and log data hundreds of meters into the seabed in tens to hundreds of meters of water.

RESULTS

Preliminary findings have determined: 1) the steep-walled, active Eel River Canyon was recently (last glacial lowstand?) fed by incised channels now buried without surface expression on the inner shelf; 2) two types of channels, both buried and modern, cross the slope north of the Eel River canyon - some were eroded into the seabed and subsequently filled by debris flows, others have developed on top of undulating seafloor (current controlled bedforms? slumps?) where equal rates of sedimentation on both thalwegs and channel walls have maintained the initial bedform geometry; 3) sediments have long accumulated at a local maximum near the 70 m isobath, suggesting reworking/erosion at shallower depths; 4) high accumulation rates have led to abundant biogenic gas in the shallow seabed that can be seen on 3.5 kHz records venting into the water column. Furthermore, this gas absorbs so much acoustic energy that across many tens of sq. km in the survey area few reflecting surfaces can be detected with seismic processing techniques applied thus far; and 5) regionally mappable reflectors were traced to where they come close to cropping out along the north wall of Eel River Canyon. D. Orange of the Monterey Bay Aquarium Research Institute was apprised of this, and he investigated these locations with MBARI's ROV "Ventana". Modern sediments appear to completely cover these valuable targets; push-cores were taken nonetheless, and the findings of paleontologic analyses are not yet complete.

IMPACT /APPLICATIONS

The extremely high and seasonally variable sediment input from Eel River does not cross the shelf in channelized flow as our profiles show that it has in the past. Whether by direct suspension load or by storm reworking, high accumulation rates are currently maintained many tens of km offshore. These deposits entomb organic material that is scavenged in the subsurface by anaerobic bacteria that in turn release considerable amounts of methane; this pore-filling gas makes it likely that few acoustic reflection techniques in these areas will be as successful as hoped. Farther offshore, both incised valleys and aggradational channels are ready conduits for sediment dispersal across the slope.

TRANSITIONS

Detailed maps of sediment thickness and structural features off Eel River will be made available to all STRATAFORM investigators. This Hi-Res profiling system will be used in an NSF-sponsored survey of the nearshore region off New Jersey in May, 1998 (G. Mountain, L-DEO, and K. Miller, Rutgers). NAVO will fund a survey of the Persian Gulf in July, 1998 (S. Swift, WHOI) using the same equipment.

RELATED PROJECTS

STRATAFORM investigators are in regular communication, pursuing parallel and complementary studies. Data will be exchanged between all investigators when complete. For example, M. Field and colleagues (USGS) have a similar project evaluating finer-scale histories of sediment geometries off Eel River using Huntec technology. The combination of Hi-Res MCS data along overlapping track lines will provide a unique and valuable assessment of sediment processes at a wide range of scales. M. Steckler (L-DEO) and colleagues are modeling depositional geometries of the Eel River shelf, and our profiles will provide them with valuable ground truth. J. Goff (UTIG) and colleagues have prepared a seabed backscatter map offshore Eel River and will be examining correlations between their findings and sub-bottom facies and structure that our profiles reveal. James Syvitski (Colorado) and colleagues are examining factors that destabilize slope sediments, and the history of mass wasting revealed by our profiles will be a valuable long-term record. Many other STRATAFORM investigators pursuing parallel efforts of understanding controls on long-term sedimentation of the Eel River margin will benefit from these high-resolution seismic data.

REFERENCES

Mountain, G., 1997, MarineCAM: A Workshop on Marine Coring at Margins, JOI/USSAC Newsletter 10(2):6-9.

http://www.ldeo.columbia.edu/MarineCAM